COLORADO RIVER PROJECT
PHASE I: WATER RIGHTS AND ALLOCATIONS

by

H. Stuart Burness
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(Supported by ERDA)

DECEMBER 1977

ENVIRONMENTAL QUALITY LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
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(For discussion at EQL Seminar, 3:00 p.m., Monday, December 20, 1976)

I. THEORY AND FUNDAMENTAL INSTITUTIONS

While this section is concerned with the institutions pertaining to the Colorado River specifically, the approach to them is tangential so as to allow the extant institutions to be embedded in the underlying set of alternative policies and institutions, and thus provide a deeper appreciation of the status quo. This serves to indicate the appropriateness (or lack thereof) of present institutions in some cases or at least their arbitrariness. As matters of equity are difficult and often impossible to assess, we observe only the legal and technical efficiency of the institutions and water laws.

A. Water as a Resource

Water is most appropriately considered a stochastically renewable natural resource. For most purposes water may be typified either as surface water or ground water* although other types such as diffused surface water and springs are recognized. Ground water can generally be considered as either underground streams or percolating water. For legal purposes the former is usually treated as surface water. Various activities differ in their consumptive use of water; some, such as recreation, wildlife refuge and preservation, power generation, maintenance of fish stocks and scenic values, consume minimal or no water at all, and may possess public or environmental as well as private characteristics.

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*Some ground water sources are nonrenewable or recharging at such a slow rate as to be so considered. Thus, strictly speaking, water supply may consist of both renewable and nonrenewable components.

As water, like air, was historically considered a free (or at least relatively abundant) good, it is not surprising that until recently many of the environmental aspects of water use and allocation were largely neglected (see [1]).

The dominant use of water has been as consumptive private use primarily in irrigation, industry, and municipal water supplies. Consequently the definition and implementation of water rights is central to the degree of efficiency obtained in the allocation of water usage. Fundamental problems in the delineation of water rights arise from both the variability of flows and uncertainty concerning the basic nature of flows. The variability of flows provides no conceptual problem although it is an impediment to straightforward policy. However, the flow uncertainty is problematic as water laws have had a tendency to precede the availability of accurate hydrologic data.

B. Property Rights

Water rights are generally considered to be real property, but this distinction is tenuous and differs with alternative water rights doctrines. Riparian water rights are based on the right of a landowner whose property is bordered by water to use that water on his land. However, the right is usufructuary so that in the strict sense the owner may not diminish the supply of water. This doctrine is interpreted so that riparians may make withdrawals that are "reasonable" in relation to the needs of downstream riparians. The doctrine of reasonable use is usually adjudicated in the courts, and interpretation may be later revised. This adds an element of uncertainty which stands as an impediment to efficient development of water rights.

In the western United States and the Colorado River Basin particularly, the doctrine of appropriation has governed water law. This doctrine is a western American innovation which emerged due to the unsuitability of the riparian system in arid lands. Rights are obtained by physically diverting water and putting it to beneficial consumptive use. While beneficial consumptive use is not clearly defined, the logic underlying the concept and its importance to the appropriation doctrine is compelling: development of the arid western states requires scarce water to be physically consumed, indicating the inappropriateness of the riparian system. Under the appropriation doctrine priorities are determined by the chronological pattern in which uses are developed: "first in time means first in right". However in times of extreme drought priorities are generally established in the order: (i) municipal and domestic; (ii) irrigation; (iii) commercial and industrial; even in this event compensation may be required for senior appropriators whose rights are temporarily usurped.

Ground water is a significant source of water supply, estimated to be more than eight times the annual supply of all rivers and fresh water lakes in the nation. Ground water law has emerged recently as surface supplies became more completely utilized, with doctrines changing as more became known about the migration, source and rate of recharge of underground aquifers. Recognition of the common property characteristic of percolating ground water led to the adoption of the doctrine of correlative rights by many states. This doctrine limits landowners' rights in the common pool to the proportion of his land to

all land overlying the pool. In many states ground water may be appropriated in much the same manner as surface water. However, several problems remain in the administration of ground water supplies: the extent of the right to have artesian pressure maintained; the extent to which ground water supplies should be mined or depleted; the extent to which ground water and surface water supplies should be integrated for more efficient administration and utilization.

There is an historical basis for the development of water rights institutions to their present form. The riparian doctrine, characterizing primarily eastern United States rivers, emanated from the English system of law, and was limited by the greater navigability of those rivers. The appropriation doctrine eminent in the later developed western rivers, and the Colorado River in particular, emerged at a time and in a place where water was essential to production and relatively limited in supply. In particular, as western development accelerated, the constraints imposed by the highly variable low-runoff of the Colorado River became apparent. While the possibility of water shortages is disconcerting, they need not be problematic with appropriate water administration. Dams can be built so as to reduce the effective variability of surface run-off, but implicit and sometimes explicit limitations on transfers have the potential to preclude the efficient allocation of water. However, it is likely that these restrictions will be relaxed when scarcity grows and alternative sources become more expensive. The nature of water laws and restrictions on transfer of water rights for each of the basin states is summarized in a later section.

C. Efficiency of Water Rights Allocations

An increase in the number and types of societal demand for water indicates that clashes with vested water rights and assigned priorities are forthcoming. Weatherford and Jacoby [2] assert that in many of the basin states this will occur in the next fifteen to twenty years, while for a few it is already present.

Limitations on the transferability of water rights exist in the form of federal, interregional, interstate, and intrastate restrictions. Federal controls stem primarily from concerns over the repayment of construction and operation and maintenance costs of storage and diversion facilities. Interregional restrictions are embodied in the Colorado River Compact of 1922, while interstate restrictions exist in the 1948 Compact (Upper Basin) and the 1973 Supreme Court decision, Arizona vs. California (Lower Basin). Intrastate restrictions stem from the historical notion that water rights should be tied to the land and, to some extent, the purpose to which the original right was assigned.

While the original and subsequent apportionment of water rights raises questions of equity, regardless of their assignment, limitations on the transfer of water rights constitute a substantive impediment to achieving an efficient final allocation of water rights. Transfer of water rights would generate a more efficient allocation and relieve misallocative pressures where they are the greatest. Reliance on the transfer of water rights is not a panacea, but it is a step in the right direction. The publicness of water suggests that government intervention may be necessary to ensure the provision and preservation

of these aspects of water resources. Likewise the possibility of a rights transfer resulting in third-party damage is not unlikely. In these cases the courts should adjudicate the damages and tie them to the transfer. Also the increasing importance of water quality, as well as quantity, attached to rights must be considered. Regardless, this would call for specific regulation rather than the general obstruction of water right transfers.

Frequently transfer of water rights has been espoused as the key to efficient allocations of water rights (e.g., see [5]). While transfer of rights to more productive uses leads to increased efficiency, it will not generally lead to an optimal allocation under the appropriation doctrine. The appropriation doctrine leaves to each subsequent appropriator a river which is relatively less desirable.

In contrast the doctrine of correlative rights would lead to a more efficient pattern of river use, as risk would be shared equally among all rights owners. While the appropriation system becomes equivalent to correlative rights when a market for contingent commodities is introduced, obstructions such as fixed diversion capacities, transaction costs, and legal impediments would tend to preclude such an occurrence. However, a modified version of such a market might lead to a second-best solution.

D. Administration of Water Rights

To further highlight the implications of central administration of water versus reliance on private markets, we indicate the potential functions that such a central authority would attempt to satisfy. They

are: (i) distributive, in that the authority would attempt to generate an "equitable" distribution of rights; (ii) allocative, in that an efficient economic allocation of rights is desired; (iii) regulatory, in that the authority needs to closely monitor the consumption and discharges of users, and gauge the behavior of the hydrosystem.

There is no reason to suspect that centrally administered rights would be more equitable than a market determined allocation. Likewise there are strong efficiency arguments in favor of competitive markets. Consequently, the central management of water supplies should be limited primarily to a regulatory function. As the Colorado River is almost completely allocated in the Upper Basin and will be overallocated in the Lower Basin with the commencement of Central Arizona Project diversions, the need for closely monitoring consumption, gauging river flow, and maintaining quality checks is obvious. Moreover certain public aspects of water need central protection and externalities need proper control. In particular the nonimpairment of rights by others must be guaranteed or compensated for in the event of impairment. While the central authority, in the form of the relevant State Engineers office or the U.S. Department of the Interior, currently executes some of these functions, more comprehensive effort will become necessary.

Developments in water law have resulted in an increased awareness of the public interest and a tendency towards greater central involvement. Some of the issues that must be faced are the trade-offs implicit in the construction and regulation of storage facilities. In particular one must align the social benefits of flood control and reduced varia-

bility in flow with the social costs of high evaporation losses. Other pressing problems are the definition of shortages and the implementation of specific policies for remedying them, the need for integration between ground and surface water management, the appropriate pricing of water, inter- and intrastate transfers, and downstream water losses.

E. Energy Development

The existence of vast coal and oil shale deposits in the Upper Basin and the need for water in processing, primarily for the removal of wastes, and for cooling purposes, poses a threat of conflict between various prospective demands for water as these energy sources are developed. An analogous situation exists in the Lower Basin, where rights are completely allocated, and there is potential need for additonal water for cooling purposes at nuclear power plants whose construction may be considered in the near future. The development of other industries and the growth of other water needs is not insignificant, but the needs of potential energy producers are unique in that their water requirements are ephemeral, either due to the exhaustibility of the resource or the possible future substitution of a water-extensive process such as the direct conversion of solar to electrical energy.

The matter of water rights, interpretations and transferability, is of paramount importance in the ultimate resolution of these issues. For example, some physical solutions have already been suggested. Jensen [3] shows that lowering Lake Mead reservoir levels will reduce evaporation losses to the extent that the water savings will enable such auxiliary power sources to generate electricity far in excess of losses in

hydropower resulting from lower lake levels. However, in view of the implied inability to meet agricultural water requirements in the event of successive periods of low runoff, it is difficult to imagine how such a solution might be generated under the existing system of water rights.

F. Summary

Water rights on the Colorado River are primarily appropriative. Any system of property rights is by nature arbitrary and subject to question on the grounds of distributional equity. Questions of equity are basically insoluble. However, water rights are encumbered by institutional appendages to the extent that the allocation of existing and potential water rights is or will be substantially distorted. Greater reliance on private markets to effect allocations with administrative involvement only to rectify externalities, insure public good properties, monitoring the river system, and policing the behavior of consumers would simplify management and improve the pattern of water usage.

II. SUMMARY OF WATER LAW

This section presents a brief exposition of legal doctrines applicable to the Colorado River Basin and separate summaries of the basin state laws. For a thorough discussion of the development of state water laws see [6].

A General Summary: Surface Water

Rights to use water can be obtained in a number of ways and once obtained can be acquired by a potential buyer through the purchase of an existing right. Substantial amounts of water are supplied by Bureau of Reclamation or Corps of Engineer projects. Corps projects usually contract storage space to water users, who have obtained rights under state law, and then impound water and make it available for delivery to those individuals. Bureau of Reclamation projects usually acquire the water right directly from the state and then wholesale such water to water districts which in turn retail the water to users with whom they have contracts. This is done at a cost which purports to amortize reimbursable construction costs and costs of operation and maintenance. Irrigation water usually is subsidized, whereas municipal and industrial water repay their full prorated share of the cost. Hydroelectric power sales amortize project costs not accounted for by the sale of water through delivery contracts.

Initially appropriative rights were obtained by merely diverting water and putting it to beneficial use. Moreover, the intended extent of use was relevant, even if the entire use was not achieved until after

a long period of time, and once accomplished the right related back to the date of original appropriation. This relating back doctrine is now limited to a shorter period, during which diversionary structures must be constructed and beneficial use accomplished. Applications must usually be filed with the State Engineer, and nonimpairment of senior rights and the public interest must be established. An approved application constitutes an inchoate right which is perfected upon demonstration of beneficial use. Applications may be lapsed if lack of diligence in completing the project is determined. Lapsed applications may be reinstated, but the priority is determined by the reinstatement date and not that of the original application.

When applications are filed, the appropriator must describe the specific watercourse and the ultimate right is limited by that description. For example, an overappropriated stream may be augmented, say, by the discharge into the watercourse of effluent ground water pumped for municipal purposes, and a new applicant may apply to appropriate this water over the protests of senior appropriators, as this source of water was not contemplated by the senior rights holders when they acquired their rights. On the other hand, a right to appropriate from a designated tributary could not, in the event of insufficient tributary flow, be supplemented by diversions from the main stem.

Distinctions are also made between beneficial kinds of use and beneficial methods of use. Beneficial kinds of use are usually irrigation, mining, manufacturing, municipal, domestic and other economic related purposes. However, water must be used efficiently as well.

Inefficient water use is illegal. The appropriative right limits use to efficient use, and appropriators can be required to alter their practices so as to achieve this goal. Rights to salvaged water may or may not be obtained depending upon whether the salvaged water was previously wasted or resulted from improved efficiency in a use that was not previously wasteful in the legal sense.

Appropriative rights may generally be sold and transferred either with or separate from the land on which the water is used. If the water is to be used in the same manner and place as previously, matters are fairly simple. However, if there is to be a change in use, an application must be filed and then reviewed and acted upon by the state water rights administrator. Perhaps the most common problem encountered is that of return streamflow. For example, a significant portion of water diverted for irrigation returns to the watercourse. If the return flow is altered by the new use, the change may not be approved or the right may be reduced to account for the alteration. In fact even the pattern of return flow is important. In irrigation return flow often takes several weeks; if the pattern of use is altered so as to affect the availability of water to downstream divertors, the upstream change in use may not be permitted.

Another problem is that some entities holding water rights, such as irrigation districts, may be prohibited from selling or transferring any part of their water rights. These restrictions were originally intended to protect the users in the district against sales of water rights which might excessively diminish the supply available to them.

However, as the directors of irrigation districts are members of the district, these restrictions actually work against the district's interest by preventing the transfer of water to more lucrative uses.

Appropriative rights are dependent on continued beneficial use of the water. Rights may be lost by abandonment when it is clearly the intent of the right holder to permanently discontinue his use of water. Loss of rights through forfeiture may occur when nonuse occurs, usually for a period of five years, but in some cases as few as two years. Rights may also be lost through prescription or adverse use. Usually this occurs when an upstream user diverts more water than he is entitled to divert and thus adverses a downstream user. If this continues for the statutory period, the right may accrue to the upstream user with the priority date of the right adversed. Many problems arose from the doctrine of adverse use, since, although the courts viewed water rights as akin to real property rights, the number of upstream users and their spatial separation from downstream users often made it difficult for a downstream user to know that he was being adversed. Consequently this doctrine is fairly uniformly rejected.

Lastly, rights may be lost by estoppel. If a right holder, for example, assists another in surveying, constructing, etc., for the purpose of diverting water for use, the former may be estopped from later claiming unreasonable use by the latter, as by his own actions he implicitly condoned the use.

B. General Summary: Ground Water

Ground water law developed on the erroneous assumption that ground

water was physically distinct and separable from surface water. In fact ground water augments surface water in the humid east, while the reverse is generally true in the arid west. Also, most ground water is percolating and does not flow in definite underground streams as was previously thought.

Before the hydrology of ground water was understood, the owner of overlying land was considered to have absolute right to use or waste water as he saw fit. Soon afterwards absolute ownership was modified by the doctrine of reasonable use. A refinement of reasonable use appears in the doctrine of correlative rights. This doctrine asserts that the owner of land overlying a ground water basin has rights to water in the amount determined by the percentage of his land to all such overlying land. In practice this doctrine is seldom applied rigidly as many overlying land owners may not be using water.

Some western states declare all waters to be public and hence subject to appropriation; the procedure is essentially the same for both surface and ground water. However some problems exist with respect to ground water as hydrologic facts are often more difficult to ascertain so that uncertainties and the possibility of impairment of existing rights are greater. A number of other problems exist as mentioned earlier such as the right to have artesian pressure and water levels maintained, the mining of ground water (extraction in excess of recharge), etc., but perhaps the most pressing is the need for integration of ground water and surface water management.

C Policies of Individual States

Arizona. Applications to appropriate surface waters are filed with the State land department and the right is perfected upon implementation of beneficial consumptive use. Competing applications for the same water supply are given the following preference: (i) domestic and municipal; (ii) irrigation and stock watering; (iii) power and mining; (iv) recreation and wildlife. Priority of the right is absolute and determined by the date of perfection. Rights cannot be enlarged, even by increased efficiency in use. Rights are viewed as an appurtenance to the land, but may be severed or transferred to other uses upon approval of the State land department provided other rights are not impaired. Such a transfer or change in use carries no loss in priority. Rights may be lost by forfeiture, abandonment, adverse use or estoppel.

Percolating ground water is treated differently and considered to be the property of the owner of the land. However, there is some modification in that the right is limited to reasonable use. Also, use may be restricted in critical ground water areas where supplies have been depleted too rapidly.

California. California recognizes both riparian and appropriation water rights doctrines. When claims conflict, appropriateive rights are held superior if they were perfected prior to the riparian right. Otherwise the riparian right prevails. Essentially these rights can be considered appropriative with priority determined by the date of right perfection.*

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*There are some execptions. See [ ] p. 135 and § 3.4.

Applications for appropriative rights must be filed with the State Water Rights Board, then circulated to specified parties. If protested, the Board conducts a hearing concerning the application, the decision being subject to judicial review if desired by the applicant. Approved applications are accompanied by permits establishing priority dates and giving the State's consent to appropriate water. However, the right is obtained only after the water is beneficially employed.

Riparian rights may be obtained only by purchasers of riparian land. Such lands are those contiguous to streams and acquired by grant from the United States, Mexico or the State of California. Once the title to land is obtained, the riparian right is established, regardless of use or nonuse. However, the right may be lost by prescription, transfer, condemnation, or estoppel. Both riparian and appropriation rights may be obtained to salvaged water. Riparian rights are limited to reasonable use vis-a-vis the uses of other riparians. Orders of priority are domestic, irrigation, and industrial.

The appropriative right is determined by beneficial use, which may not exceed the quantity stated on the permit. Priorities are determined by chronological perfection of the right and also according to the same use pattern as the riparian right. Appropriative rights may be transferred by changes of place of use, nature of use, point of diversion, and diversion works provided the rights of others are not impaired. Riparian rights are appurtenant to the land but may be severed if there is no injury to other riparians and they consent to the transfer. However, irrigation districts are prohibited from selling water

rights or leasing for a contract period exceeding three years. Transfer of rights results in no priority loss except that due to altered use.

Ground water in California is either (i) water underflowing a water course; (ii) definite underground streams; (iii) percolating waters. The first two are treated as surface water, while the third is subject to the doctrine of correlative right. Underground waters are assumed to be of the third type unless determined otherwise. The correlative right is very similar to the riparian right except the right of the overlying owner is always an appurtenance to the land. The correlative right is limited only by the reasonable needs of other overlying owners. It is a private right so that a city can mine underlying water only after obtaining legal title to the overlying land. Due to the possibility of salt water intrusion, withdrawals in excess of natural recharge are prohibited.

Nevada. After considerable vacillation Nevada has adopted the doctrine of appropriative rights. Applications for rights are filed with the State engineer who then determines the ultimate form of the right. In the event of conflicting interests he resolves the issue and forwards his recommendation to the appropriate district court where the issue is adjudicated. The right is perfected subsequent to proof of beneficial consumptive use.

All water, whether surface or ground, belongs to the public. Water may be appropriated for any recognized beneficial use: irrigation, power, municipal, mining, stock-watering and recreation. Chronological priority is limited by beneficial use; appropriations cannot legally exceed

beneficial use. Appropriations may be restricted to certain portions of the year. Moreover a senior downstream appropriator may have to forfeit water to a junior upstream appropriator if the water reaching the former is insufficient in quantity to be used beneficially. Transfer or changes in place or purpose of use or point of diversion may be approved provided there is no impairment of other rights, including those of junior appropriators. Rights may be lost only by forfeiture or abandonment. Rights may be acquired to saved or developed waters. While ground and surface water are treated the same, use of ground water may be restricted if the State engineer determines that a ground water basin is being depleted.

Colorado. Colorado has always been an appropriation state, and by completely abrogating the riparian doctrine, the pure appropriation doctrine was first known as the Colorado doctrine, as opposed to the California doctrine which attempted to recognize both appropriation and riparianism. Water administration comes under the State engineer, district engineers, and court-appointed district water judges. Rights to divert and put unappropriated water to beneficial use are undeniable, and are initiated by actual diverting water and putting it to beneficial use. Recognized beneficial uses are domestic, agricultural, industrial, municipal and recreational. Priorities of a right are adjudicated by the water judge, and priority dates may differ from dates of appropriation initiation. Priorities may also be obtained for conditional water rights (i.e., those attached to projects requiring a lengthy construction period); upon completion the date relates back to the initial physical demonstration of intention to appropriate.

Ownership of unappropriated water is public subject to appropriation. The right is transferable either as an appurtenance to the land or severed from it. However, a change of water right (change of type, place, time of use, point of diversion, or storage) must be approved by the water judge conditional to nonimpairment of vested rights and subject to possible limitations necessary to protect such rights. Rights may be lost only by abandonment and in a limited degree by adverse use.

Ground water is either tributary ground water or nontributary ground water. Unless otherwise determined, ground water is assumed to be of the former type and hence subject to appropriation. The latter type is subject to a modified version of the appropriation doctrine, limited sometimes due to the common property characteristic and the overdraft problem, but generally can be considered subject to the law of appropriation.

New Mexico. The law of prior appropriation had been established in New Mexico before it became a territory in 1850. Unappropriated water belongs to the public and is subject to appropriation. Generally an application is submitted to the State engineer, and if a right is granted its priority relates back to that on the application; to be approved an application must be in the public interest. The State engineer may reduce the amount of the request or alter the period of annual use of water. An approved application specifies a time by which the water must be put to beneficial use. Rights are perfected for the amount ultimately used beneficially not exceeding the requested amount. Beneficial use is not specified by either court ruling or statute.*

*Potential vacationers should be aware that in New Mexico travelers may not be refused water.

Rights may be changed or transferred without loss of priority; however, any such action must carry the approval of the State engineer indicating the nonimpairment of other rights. Rights may be lost by forfeiture, abandonment, while adverse use and estoppel have only minor importance. All ground waters are public and subject to appropriation. In a recent decision the courts upheld the State engineer's decision to limit use of a nonrechargeable aquifier to a rate which would leave one third in storage after 40 years. It is incumbent on appropriator of ground water to exhibit nonimpairment of existing rights.

Utah. Utah has explicitly adopted the appropriation doctrine and repudiated the riparian system. All water above or below ground is considered to be public and subject to appropriation for beneficial use. The State engineer is delegated chief administrative responsibility in water matters, but ultimate decisions are adjudicated in district court. Applications to appropriate are filed with the State engineer. After posting general notice of the application and determining nonimpairment of other rights and confirming the physical and economic viability of the plan, the State engineer may approve the application which is then considered an inchoate right. Perfection of the right occurs when the water is diverted and put to beneficial use. After this the right may be adjudicated for final determination.

Priority is determined by the application date. There is no specific preference among competing uses and such conflicts are resolved on an ad hoc basis. However, in time of shortage there is a preference for domestic over agricultural over all other uses. Changes or transfers of

right must be approved by the State engineer subject to the nonimpairment of existing rights both junior and senior. In addition users are allowed to exchange water by storing water in one place and diverting a like amount (less evaporative and seepage losses) at another. Rights may be lost by forfeiture, abandonment, or estoppel, but not by prescription. Salvaged or developed water accrues to the developer. Ground water is subject to the same procedure and rights as surface water; reductions in well pressure are allowed, although limited, vis-a-vis the common property characteristic.

Wyoming. All water in Wyoming is State property and subject to appropriation except when such use would be contrary to the public interest. Due to the aridity of the State the riparian doctrine was repudiated, as the appropriation doctrine was better adapted to the area. Applications to appropriate are filed with the State engineer who may approve the request subject to the nonimpairment of other rights. Perfection of rights requires proof of beneficial use. Preferred uses are recognized but not listed exhaustively; preferred uses include domestic, municipal, steam, power plants, and industrial. Changes and transfers are not allowed except when such a transaction leads to a more preferred use of water. However, there are some exceptions to this rule and the unconstitutionality of the restriction has been determined in some cases. Water rights may be lost through forfeiture or abandonment and to a limited degree through prescription or estoppel. Ground water is treated essentially the same as surface water, although applications may be denied in critical areas.

III. LEGISLATION, LITIGATION AND RIGHTS ALLOCATION

This section summarizes the content and import of the primary legal institutions concerning the Colorado River and relates their implications for rights allocations or, in some cases, their ambiguity in such matters.

Reclamation Act (1902). The impetus for development of the Colorado River was provided initially by the Reclamation Act of 1902. This act created the Reclamation Service and encouraged "family farm" development of irrigable areas of the Colorado River. Since it limited individual water rights to irrigate a maximum of 160 acres, efficient development of irrigated lands was later inhibited.

The Reclamation Act strengthened demands for a storage facility, most likely in either Black or Boulder Canyon, and an All-American Canal for the Imperial Valley in Southern California. Until that time irrigation water had been routed through Mexico via the Alamo Canal. The more slowly developing Upper Basin states opposed Lower Basin storage as they feared the more developed Lower Basin states would appropriate excessive water rights and consequently inhibit future Upper Basin development. The desire for development in the Lower Basin and the fear of loss of water rights in the Upper Basin led to the ultimate division of the waters in the Colorado Compact of 1922.

Colorado Compact (1922). The desire for storage by Lower Basin states was compounded by the danger of floods and problems of dual sovereignty arising from the Alamo channel. The Upper Basin fears had solid foundation in light of the Supreme Court's 1922 endorsement of

"prior appropriation" as the governing principle in equitable apportionment litigation. Consequently the Colorado River Commission was appointed and in the brief space of two weeks generated the Colorado River Compact. Ratification by the required six of seven states did not occur until 1928 with Arizona withholding until 1944. The Compact was approved by Congress as part of the Boulder Canyon Project Act (1928).

The Compact is plagued with a lack of clarity at places, representing a lack of foresight or just the realization that attempts to clearly delineate all provisions may have precluded mutual agreement. The cost, of course, is that controversies must be settled by litigation, a time-consuming and expensive process that may overlook efficient settlements.*

The Compact designates Lee Ferry as the dividing point between the two basins. It recognizes the likelihood of a treaty with Mexico and requires that the treaty obligations be discharged equally by both basins. It assigns 7.5 MAF of water yearly to the Upper and Lower Basins. While the Lower Basin was allowed to increase its rights by another 1 MAF, this provision is relatively unimportant as the runoff of the Colorado was substantially overestimated at the time the Compact was signed. Ultimately the dominant provision of the Compact was the Upper Basins' requirement to deliver 75 MAF of water at Lee Ferry during every ten year period. Thus the Upper Basin shouldered the burden of stream variability and permanent or cyclic reductions in mean runoff. Depending on the time period selected, the average virgin flow of Lee Ferry varies from 13 to 15 MAF.

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*For an excellent discussion of congressional versus judicial apportionment, see Meyers.

Tree ring studies conducted by the Lake Powell Research Project have determined that the early 1900's was one of heaviest flow periods in the river's history and that the runoff since 1930 is representative of the average flow during the last four centuries--about 13.5 MAF per year. Thus the Upper Basin's allocation is reduced by 20 percent prior to meeting Mexican obligations and evaporation losses. The Lower Basin has available for consumption at Lake Mead the delivered 7.5 MAF plus inflows minus reservoir evaporation and channel losses between Lee Ferry and final points of diversion. Lake Mead evaporation averages 0.8 MAF, while net inflows between Lee Ferry and Lake Mead average 0.8 MAF. Thus 7.5 MAF should be available for consumption at Lake Mead* minus any obligations to Mexico.

It is not clear whether the Lower Basin's option to exercise rights over an additional 1 MAF stems from the estimates of average runoff at the time (1899 to 1920 flow at Lee Ferry was 16.4 MAF) or from consideration of the Gila River, which in 1923 was discharging an average of 1.1 MAF yearly into the Colorado. While the Compact asserted that all tributaries of the Colorado were to be considered in the allocation of rights, no mention was made of Arizona's consumption as of that time of 2.3 MAF Gila River water, much of which was annually replaced groundwater. However this confusion is most likely irrelevant: (i) it seems unlikely that runoff will be high enough during the future to allow any additional claims; (ii) in Arizona v. California (1963) the Supreme Court determined

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*See Table 2 in the Appendix for quantities available on a yearly basis.

that Arizona should not be charged for Gila River water consumption as pertaining to the 1922 Compact. By 1963 Arizona was almost completely consuming the Gila; on the average only about 1000 acre-feet was actually discharged into the Colorado and sometimes the contribution was as low as 300-400 acre-feet per year. Arizona argued that since the Gila River lay entirely within her boundaries and emptied just above the Mexican border, no other state could efficiently use the water, and hence Arizona should not be charged under the 1922 Compact. Apparently the Supreme Court accepted this argument.

The Compact indicates a preference for agricultural and domestic uses of water over use for power generation, and it declares present perfected rights of downstream users to be unimpaired in the event that Upper Basin storage facilities are later developed. The latter provision, conjoined with the former, resulted in conflict between the two basins subsequent to construction of Glen Canyon Dam.

There are a number of problems which arise either as a result or in spite of the Compact. First "beneficial consumptive use" depends upon the accounting procedure used to measure consumption. The Upper Colorado River Compact adopted the "net depletion" of virgin flow method, in which use of salvaged water which would have been lost anyway due to natural causes (i.e., a flooded meadow) would not be charged to the user. The Boulder Canyon Project Act, which allocated water among the Lower Basin states, adopted the "diversions less return flows" method, which charges users with actual consumption at the site of use. In Arizona v. California the Special Master interpreted the Compact as adopting the "diversions less return flows" rule.

A conflict resulted from the Lower Basin's right to surplus waters as opposed to the superiority of domestic and agricultural rights over power generation. Roughly, the conflict is resolved to some extent by providing for accumulation in Lake Powell for future domestic and agricultural use subject to the condition that the levels of Lake Powell and Lake Mead be equalized. Other problems include the provision of Mexican requirements, which is discussed below, water quality, which was not mentioned in the Compact, and the treatment of ground water. It appears that ground water use would be considered as consumption towards the appropriative limit in view of the Supreme Court's support of the "diversion less return flows" method of accounting.

Boulder Canyon Project Act (1928). The Boulder Canyon Project Act is the vehicle that transformed the Colorado River Compact into law. Additionally it provided for the construction of Boulder Dam, first known as Hoover Dam,* in Boulder Canyon, although it was ultimately located in Black Canyon, some 20 miles downstream. Also it allocated Lower Basin rights between the three states with California receiving 4.4 MAF, Arizona 2.8 MAF, and Nevada 0.3 MAF. In 1963 the Supreme Court used this act as the sole basis in resolving the water litigation between California and Arizona. However, the act did not address the treatment of evaporation losses or the allocation of shortages.

Arizona v. California. As early as 1921 Arizona had been contemplating a high line canal to divert Colorado River water to central

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*In 1947 Congress determined that the dam in Black Canyon should be known as Hoover Dam.

Arizona.* This culminated in the Central Arizona Project, Arizona's prime objective since she finally ratified the Boulder Canyon Project Act in 1944. Although the Project Act allocated 2.8 MAF of water to Arizona, she was unable to use this water in its entirety and feared that California might perfect rights by appropriating water that Arizona was not consuming at that time. These fears were perhaps not unfounded, as California has been consuming Colorado River water in quantities close to 1 MAF in excess of her allotted 4.4 MAF.

From the time the Boulder Canyon Project Act was signed into law in 1929, Arizona took California to the Supreme Court five times (1931, 1934, 1935, 1936, 1963). The first four suits were disallowed, but the most recent suit (in 1963) was decided on the basis of the allocations prescribed in the Boulder Canyon Project Act. The only headway that Arizona made resulted from the decision of the Special Master to determine allocations during times of drought on the basis of 44/75 of appropriations to California, 28/75 to Arizona, and 3/75 to Nevada. However Arizona's gain was for practical purposes obliterated when Congress gave California absolute water rights to 4.4 MAF with priority over the Central Arizona Project in the event of a shortage.**

The Supreme Court decision in Arizona v. California, however, provided a subtle victory for Arizona in another way. In 1951 a House Committee resolved to postpone consideration of the Central Arizona Project until the use of Colorado River water by the Lower Basin states

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*See Hendley, p. 121.

**See Colorado River Basin Project Act, 43 USC § 1521(b) 1971.

was either settled by mutual agreement or in the courts. Previously, the courts had in general refused to allocate future rights, preferring to intercede only when present appropriations were overallocated. Arizona appeared to be in a quandary: without water she could not get the canal, and without the canal she could not get water. However, the Special Master affirmed Arizon's right to 2.8 MAF of Colorado River water, and the day after the Supreme Court decision, the Arizona senators presented a bill to authorize the Central Arizona Project.

Certain other issues of importance were resolved in this Supreme Court decision. First, the Gila River was excluded for accounting purposes in determining Arizona's yearly consumption. Arizona consumes about 2 MAF per year from the Gila River, but the river is entirely within Arizona and contributes only negligible amounts to the Colorado at its mouth. In the event that the decision had been reversed on this issue, California could have increased its consumption by about 1 MAF per year. Second, the Secretary of the Interior, on the direction of Congress or at his own discretion, was to allocate water among the Lower Basin states in the event of a shortage. Among the methods that he might adopt was the basis of existing contracts: 44/75 to California, 28/75 to Arizona, and 3/75 to Nevada. In no case, however, was California to be allocated more than 4.4 MAF. The third point of particular interest was the entitlement of Indian reservations and other federal establishments to use water to the extent of the purpose for which they were created, with rights perfected as of the date the unit was established.

The Mexican Treaty (1944). The Colorado River Compact, in somewhat vague terms, mentioned the possibility of a future treaty with Mexico. Presidential authorization to meet with Mexican representatives to study the equitable division of the Rio Grande below Fort Quitman occurred in 1924, but Mexico, sensing that her bargaining position would be improved, insisted that the Colorado be included as well. In 1927 the investigation was broadened to cover the two rivers jointly. Mexico's bargaining strength in this scenario came from her need for Colorado River water aligned with her control of 70 percent of the Rio Grande's tributary inflows.

In 1944 the Mexican Treaty was signed. There was an equal division of the Rio Grande waters below Fort Quitman, to which Mexican tributaries contributed 70 percent, while Mexico received nearly 10 percent of the average annual runoff of the Colorado River (16 MAF being the figure used at the time). Mexico and Texas appeared to have benefited at the Colorado Basin states expense. Specifically the treaty provided that Mexico would be guaranteed annually 1.5 MAF from the Colorado and that in times of surplus up to an additional 200,000 acre-feet, but that no rights could be acquired in excess of 1.5 MAF. The possibility of reducing deliveries to Mexico was considered but subject to conditions: (1) extraordinary drought; (2) difficulty in making the specified deliveries; (3) reduction in United States consumptive uses. The existence of immense storage capacities in the Colorado River Basin make it unlikely that (3) would occur, and conjoined with the vagueness of (1) and (2), it appears that reduction of deliveries to Mexico is extremely unlikely.

The delivery schedules specify maximum and minimum rates of delivery, the limits varying at different times of the year, and provide for 1 MAF from the main stem and 0.5 MAF from the All-American Canal to be delivered annually until 1980 with the respective figures being 1.125 MAF and 0.375 MAF after 1980. Ultimately this scheme was not followed. Currently 1 MAF is delivered through the All-American Canal, primarily so as to minimize channel losses, and to some extent so as to leave undisturbed a section of the Mexican main stem which has been developed into a park area. Each basin is responsible for delivering one half of the required amount or 0.75 MAF. However, 0.75 MAF delivered at Lee Ferry by the Upper Basin would be substantially less than that by the time it reached the border due to heavy channel and evaporation losses. The question of the accounting delivery point may have to be settled by litigation, as it is not spelled out in the treaty.

The treaty is also vague about water quality. Pollution occurred much more quickly than expected, emanating from an irrigation project in the Wellton-Mohawk District. There a drain was constructed to empty the discharge directly into the Colorado so as to charge this amount towards the Mexican requirement. The effluent contained approximately 6000 to 6500 parts per million (ppm) of dissolved solid and resultantly increased salinity at the Mexican border from 1100 to 2700 ppm. To avoid potentially embarrassing litigation or arbitration, the Wellton-Mohawk drain was extended so that discharges could bypass the Mexican diversion works at Morelos Dam during the low flow winter months. Further measures to improve water quality were implemented in 1974 when President Nixon signed the

Colorado River Basin Salinity Control Act authorizing the construction of desalinization plant at the border.

Upper Colorado River Basin Compact (1948). The Upper Basin desired to allocate rights among its several states for a very simple reason: development was progressing but limited by a lack of storage facilities to provide carryover during periods of low runoff; the primary source of finance was the federal government who insisted on rights settlement before putting up any funds. Relative to the Lower Basin's experience, the settlement came quickly, for none of the states could gain by delaying.

The Upper Basin states, realizing the highly variable runoff of the Colorado, allocated rights on a percentage basis. With exception of Arizona, who in view of her minimal claims as an Upper Basin state was given a flat grant of 50,000 acre-feet yearly, the allocations were: Colorado, 51.75 percent; Utah, 23 percent; Wyoming, 14 percent; New Mexico, 11.25 percent. The Upper Basin adopted the inflow-outflow method of delivering consumption so that incentive was provided for salvaging channel or other natural losses. While this encourages the efficient use of water, it also biases estimated consumption figures downward as there is no immediate way to obtain actual on-site consumption. Recall that the Lower Basin adopted the diversion less return flows formula which was later determined by the Special Master in Arizona v. California to apply to the Colorado Compact as a whole.

The percentage allocations apply only to the 7.5 MAF allocated to the Upper Basin by the 1922 Compact. During a surplus additional alloca-

tations would be determined by the 1922 Compact. During a shortage the percentages would not be used to determine curtailment. Instead states would have to deliver to Lee Ferry their overdrafts for the preceeding ten years, and, this failing to eliminate the deficiency, each state would reduce its present consumption by the relative percentage of its use during previous years (to 1922) and in a magnitude such that the aggregate would remedy the deficiency at Lee Ferry.

The Upper Basin was also farsighted enough to allocate reservoir losses. For a facility designed to provide storage for in-state use, the state bears the loss, while for facilities intended to help meet the Lee Ferry obligation, each state is charged with losses in proportion to the ratio of its own to total consumptive use.

While the Upper Basin Compact was intended to divide the Upper Basins allocated 7.5 MAF, this must be interpreted in light of the 1922 Compact and the express commitment on the part of the Upper Basin to deliver 7.5 MAF to the Lower Basin. As mentioned earlier the reconstructed average virgin runoff at Lee Ferry is approximately 13.5 MAF. Subtracting the Lower Basin commitment and the 0.75 MAF requirement to Mexico leaves only 5.25 MAF available for Upper Basin consumption, and this figure must be diminished by the average evaporation in Lake Powell (0.6 MAF).

Upper Colorado River Storage Project Act (1956). As soon as the Upper Colorado River Basin Compact was approved by Congress in 1949, the Upper Colorado River Basin Commission, established by this Compact, began urging the approval of the Colorado River Storage Project Act. This work culminated in 1956 when the act was approved and construction of storage

facilities at Curecanti, Flaming Gorge, Glen Canyon, and Navajo were authorized. The Glen Canyon facility was by far the largest with a maximum storage capacity of 27 MAF, while the other facilities were roughly an order of magnitude smaller. The closing of Glen Canyon Dam in 1964, a relatively low flow year (10.2 MAF), resulted in 5.6 MAF retained and only 2.4 MAF released from the dam. In 1965, a high flow year (18.9 MAF), 4.9 MAF were retained and 10.8 MAF released. The closing of Glen Canyon Dam led to controversy between the Upper and Lower Basins concerning the priority to retain water for power and future domestic and agriculture in the Upper Basin versus additional power generation and current expansion of domestic and agriculture activities in the Lower Basin. In 1968 Secretary of the Interior Udall ordered that Lower Basin deliveries be lowered by 10 percent to facilitate the filling of Lake Powell. Nonetheless the ten year period ending in 1973 showed deliveries of 82.9 MAF to the Lower Basin, which only barely exceeds the compact requirements (75 MAF for the Lower Basin plus 7.5 MAF, the Upper Basin charge for deliveries to Mexico).

Colorado River Basin Project Act (1968). Arizona's reluctance to ratify the Colorado River Compact was understandable since it provided no protection against California, it offered no equivalent to the Boulder Canyon Project, it did not restrict Mexico's development, and, by allocating water to the Upper Basin, it limited the quantities of water to which she might lay claim. When Arizona finally signed in 1944, her prime objective became a high-line canal to the Phoenix-Tucson area. Her efforts were rewarded in 1963 following the Supreme Court's final decree

in Arizona v. California. After five years of negotiations the canal was authorized as the Central Arizona Project. However, California approval was bought at the Cost of a major concession: an absolute priority for Califonia of 4.4 MAF. Thus the viability of the Central Arizona Project depends on the importation of 2.5 MAF of water yearly into the Colorado River Basin: 1.5 MAF to satisfy the Mexican Treaty and 1 MAF allowed for losses. At that time there would be adequate water to supply 4.4 MAF to California, 2.8 MAF to Arizona, and 0.3 MAF to Nevada.* However, strong protest from Pacific Northwest representatives resulted in the inclusion of another provision banning interbasin transfer studies for ten years. In this form the bill was approved in 1968 and became known as the Colorado River Basin Project Act. The authorized cost of the project was 1.3 billion dollars and the project has met with continued opposition along the way. Scheduled completion is around 1985.

As a result of the interbasin clash concerning the use of surplus water for Upper Basin storage versus Lower Basin power, the Colorado River Basin Project Act also instructed the Secretary of the Interior to develop criteria for the operation of federal reservoirs. Water was to be released from Lake Powell with priorities: (i) the treaty obligation to Mexico; (ii) the Lower Basin's right to 75 MAF per ten years; (iii) maintenance of carryover storage necessary for (i) and (ii). Detailed criteria for maintaining parity in storage levels between Lakes Mead and Powell were published by the Secretary of the Interior in 1970.

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*See Meyers, p. 73.

Federal and Indian Rights. In the Arizona v. California final decree Indian reservations and other federal establishments were allocated rights to use water in an amount sufficient to guarantee use of the land for the purpose it was established. Priority and perfected right status were determined as of the date the establishment was created. Although the 1922 Compact and the Upper Basin Compact asserted that Indian rights would not be affected, these rights were not then delineated. Tribal water claims are based on the Winters doctrine, which claims that the water rights are preserved with the reservation of the land.

While many Indian rights have not been quantified, some have been. In Arizona v. California some Lower Basin Indian rights aggregating about 1 MAF were specified. When unquantified and unexercised Indian and federal rights are asserted, further shortages can be expected with accompanying litigation.

IV. HISTORICAL PATTERN OF USE OF THE COLORADO RIVER

Despite the lengthy and complex negotiations concerning water rights to the Colorado River, in fact the river has never been over-appropriated in use; the battle over rights is concerned with the future shortages that will occur, perhaps as soon as the late 1980's. In this section, we summarize the historical record of flows of the Colorado River, together with the pattern of use of the river.

Lee Ferry is the dividing point on the river between the Upper and Lower Basin states, and represents the base position so far as measured flows of the river are concerned. The approach adopted by the Bureau of Reclamation is to "reconstruct" the so-called "virgin flow" of the river at Lee Ferry for each water year. (Each water year ends on September 30.) The reconstruction is accomplished by measuring the actual flow of the river at Lee Ferry (or, more precisely, at two monitoring positions located near Lee Ferry). To this physical flow are added several estimates: an estimate of depletions that have taken place during the year in the Upper Basin upstream from Lee Ferry; an estimate of increases in reservoir storage in the Upper Basin during the year (increases in surface storage at upstream reservoirs plus increases in bank storage at such reservoirs); and to this subtotal is added an estimate of evaporation losses at upstream reservoirs. The resulting figure, actual flows at Lee Ferry plus Upper Basin depletions plus increases in Upper Basin reservoir storage plus evaporative losses at Upper Basin reservoirs, is the estimate of the reconstructed virgin flow at Lee Ferry for the water year. The

reconstructed virgin flow figure is thus an estimate of the quantity of water that would have flowed through Lee Ferry in the absence of man-made depletions and storage facilities in the upper stream.

The appendix to this paper contains several tables giving detailed data on water availability and use for the Colorado River. Appendix Table 1 presents a detailed breakdown of physical flows at Lee Ferry and estimated virgin flows for the period 1896-1975. A summary of these data is the following.

Average Annual Historical and Virgin Flows at Lee Ferry
Selected Periods, 1900-1975
(all data in thousands of acre-feet)

Period	Historical flows	Upper Basin depletions	Changes in U.B. storage	Evap. losses U.B. reser.	Virgin flow
1900-09	15,140	1,100	--	--	16,130
1910-19	15,500	1,660	--	--	17,160
1920-29	16,190	2,000	--	--	18,190
1930-39	10,750	1,710	--	--	12,460
1940-49	12,650	1,890	--	--	14,540
1950-59	10,810	2,030	--	--	12,840
1960-69	7,930	2,320	2,140	170	12,570
170-75	9,050	2,850	2,850	530	15,180

Source: Bureau of Reclamation

The historical flows column of the above table shows the average annual measured physical flow of water at Lee Ferry for each period. It is clear that prior to the 1960's the Compact imposed no constraint on the amount of water that was made available to the Lower Basin states, since physical flows far exceeded the mandated deliveries from the Upper Basin

to the Lower Basin. With the closing of Glen Canyon and the other storage dams in the Upper Basin in the early '60's, deliveries of water at Lee Ferry begin to approximate the Compact requirements. Note also that depletions in the Upper Basin plus evaporation losses at Upper Basin reservoirs (both chargeable to the Upper Basin under the Compact) are still, in the most recent period, only 50 percent of the 6.75 MAF per year allocated to the Upper Basin under the Compact. The percentage rises to over 60 percent, however, if the projected annual virgin flow of the Colorado is reduced from 15 MAF to 13.5 MAF per year, with the Upper Basin bearing the burden of its guaranteed deliveries of 75 MAF each ten year period to the Lower Basin (plus 7.5 MAF for the Upper Basin share of Mexico deliveries).

The virgin flow column gives a clear indication of the unusually high flows in the first three decades of this century relative to later periods, and the consequent overallocating of the river by the signers of the Compact.

Finally, the table indicates that the character of the policy problems involved in the Colorado River region changed markedly beginning with the 1960's. Upper Basin depletions had shown only a gradual growth over time up to the closing of Glen Canyon, but they are now increasing at a rapid rate. At present rate of increase in depletions, the Upper Basin will have met or exceeded its allocation of 5.25 MAF per year (assuming a 13.5 MAF per year virgin flow) by 1990. In anticipation of this eventuality, almost 40 MAF had been stored in Upper Basin reservoirs (including both bank and surface storage) by 1975. This in turn

has led to a substantial amount of evaporation losses, amounting annually to 10 percent of the Upper Basin allocation for the period 1970-75.

Turning to the Lower Basin, we can inventory its water situation as follows. The Lower Basin receives as its primary water input the physical flow of the Colorado at Lee Ferry, to which is added the flow of tributaries entering the mainstream below Lee Ferry (primarily the Little Colorado, Bill Williams River, and the Gila River), plus intermittent flows from minor rivers and washes. Offsetting these additions to the mainstream are evaporative losses that occur between Lee Ferry and the points at which diversions take place. While historical data are not available for as long a period for the Lower Basin as for the Upper Basin, relatively complete information is available for the period 1964-73. These data are presented in Appendix Table 2. We summarize this information on availability and uses of mainstream water for the Loser Basin in the following table.

Average Annual Availability and Use of Mainstream Water,
Colorado River, Lower Basin, 1964-1973
(all data in thousands of acre-feet)

Availability	Annual Average, 1964-73
Historic flow at Lee Ferry	8,272
Net Inflow, Lee Ferry-Lake Mead	868
Inflow, Lake Mead-North Border	87
Total Mainstream Water Available	9,227
Uses	
Net diversions, Lower Basin	6,484
Increase in storage, L.B. reservoirs	407
L.B. reservoir evaporation losses	706
Channel and other losses	258
Flow at North Border	1,372
Total Mainstream Water Uses	9,227

Source: Bureau of Reclamation

As indicated in the table, deliveries to the Lower Basin at Lee Ferry over the period 1964-73 almost exactly match the Compact requirements of 8.25 MAF per year (7.5 MAF for Lower Basin use, .75 MAF of Upper Basin deliveries to meet the commitment to Mexico) each ten year period. To these deliveries were added 955,000 acre-feet in Lower Basin tributary flows, but these are offset by 964,000 acre-feet of losses per year (reservoir evaporative losses, and channel and other losses). Thus, during the 1964-73 period, the Lower Basin had available for consumptive use essentially its Compact allocation of 6.75 MAF per year, after providing for deliveries to Mexico. The allocation was not completely used, as is indicated by the fact that reservoir storage increased an average of 407,000 acre-feet per year. Data shown in the table are somewhat misleading as to consumptive use in the Lower Basin and deliveries to Mexico. Consumptive use in the Lower Basin is defined as diversions from the river less returns to the river. As it turns out, some 140,000 acre-feet per year of returns to the river occur below the North Border point. These returns must be added to the flow at the North Border to obtain deliveries to Mexico, and must be deducted from the net diversions figure to obtain an estimate of consumptive use in the Lower Basin. Thus average annual consumptive use for the 1964-73 period in the Lower Basin was approximately 6,344,000 acre-feet, some 406,000 acre-feet below the 6.75 MAF allocated under the Compact. The Lower Basin thus used roughly 94 percent of its allocation over the 1964-73 period.

While total consumptive use of the Colorado River by the Lower Basin in recent years closely approximates the Lower Basin allocation

under the Compact, the pattern of use among Lower Basin states differs markedly from the allocation decreed in Arizona v. California. The Supreme Court allocated 4.4 MAF per year to California, 2.8 MAF to Arizona, and .3 MAF to Nevada, all to be reduced on an equitable basis to meet requirements for deliveries to Mexico. Assuming a prorata sharing of Mexican deliveries, the Arizona v. California allocation is 4.0 MAF to California, 2.52 MAF to Arizona, and .27 MAF to Nevada. Actual consumptive use over the 1964-73 period was 5.096 MAF annually by California, 1.162 MAF annually by Arizona, and 48,000 acre-feet annually by Nevada. (See Appendix Table 3 for detailed data on consumptive use by states within the Lower Basin.) In 1974, California's use had increased to 5.4 MAF, Arizona to 1.3 MAF, and Nevada to just under 100,000 acre-feet, amounting to a total of 6.8 MAF.

What this means for the future is that when the CAP comes on line, Arizona will be using its full quota of 2.52 MAF; California use must be cut back from its 1974 level by 1.4 MAF; and Nevada can expand its usage by some 170,000 acre-feet per year. Within California, assuming that the appropriative system is applied strictly on the basis of seniority, the Metropolitan Water District will be cut back substantially (to perhaps 150,000 acre-feet per year from 1974 consumption of 1,122,000 acre-feet), with only minor cutbacks for the Imperial Valley, Coachella Valley, Palo Verde and Yuma Irrigation Districts. Appendix Table 4 summarizes consumptive use by major users within California, Arizona, and Nevada for the period 1964-74. As noted earlier, usage by present holders of rights will also be affected by

the amount of water allocated to Indian reservations under Arizona v. California and subsequent litigation. Within Arizona, the Colorado River Indian Reservation has increased its consumptive use from 180,000 acre-feet in 1964 to 298,000 acre-feet in 1974, and is now the second largest user in Arizona.

A matter of central importance to the management of the Colorado River is water storage policy. There are nine major storage reservoirs on the Colorado, six located in the Upper Basin and three in the Lower Basin. Lake Powell behind Glen Canyon is the largest of the Upper Basin reservoirs, and Lake Mead is the largest in the Lower Basin. Until 1963, when Glan Canyon was closed, the Upper Basin had little or no control over flows to the Lower Basin, resulting in deliveries far in excess of the Compact requirements. Glen Canyon was built just north of Lee Ferry, so that no uncontrolled Upper Basin tributary flows now enter the Lower Basin. Since Upper Basin use of the Colorado is substantially less than its allocation under the Compact, and since the Upper Basin now delivers essentailly its mandated quantities to the Lower Basin, there has been a buildup of storage in Upper Basin reservoirs since 1963, amounting to approximately 40 MAF by 1975 (includes both surface and bank storage). Over the same time, Lower Basin reservoirs have increased storage levels as well, but at a much slower rate. Appendix Tables 5 and 6 present data on storage levels and changes in storage for the nine storage reservoirs, 1964-75. The status of the storage reservoirs as of September 30, 1975 is summarized in the following table.

USABLE CAPACITY AND ACTIVE STORAGE
COLORADO RIVER RESERVOIRS
SEPTEMBER 30, 1975
(thousands of Acre-Feet)

UPPER BASIN	GROSS CAP.	USABLE CAP.*	ACT. STORAGE**	%STOR./US. CAP.
Lake Powell	27,000	25,002	20,202	80.8%
Flaming Gorge	3,789	3,749	3,650	97.3%
Navajo	1,709	1,696	1,393	81.8%
Blue Mesa	941	830	695	83.6%
Fontenelle	345	345	329	95.4%
Morrow Point	117	117	116	99.1%
Total	33,901	31,739	26,385	83.3%
LOWER BASIN				
Lake Mead	28,537	26,159	20,154	77.0%
Lake Mohave	1,818	1,810	1,385	76.5%
Lake Havasu	648	619	573	92.4%
Total	31,003	28,588	22,112	77.3%
Colorado River Total	64,904	60,327	48,497	80.4%

Source: Annual Reports, Colorado River Board of California, 1964-1975.

*Usable capacity is less than gross capacity by the amount of loss in capacity due to sedimentation accumulations in the reservoirs.

**Active storage includes only surface storage; bank storage is excluded.

As of September 30, 1975, 80 percent of the active storage capacity on the Colorado River was being used, with Lower Basin reservoirs having a slightly larger amount of available capacity than Upper Basin reservoirs. With over 48 MAF of surface storage, reservoir evaporation losses for the entire system had reached 1.5 MAF for the year 1975, something over 10 percent of the virgin flow of the river. There were 12 MAF of available surface storage capacity on the river as of September 30, 1975. At the rate of increase in surface storage for the 1975 water year (approximately 3.6 MAF), the storage capacity of the system would

be fully utilized by 1978. Actually, the situation is even tighter than these numbers indicate, since a part of the usable capacity of the system must be set aside for flood control purposes, the amount varying with the time of year; there must be excess capacity of at least 1.5 MAF in the fall of the year, and at least 5.35 MAF of excess capacity on January 1 of each year, in order to meet the requirements of the Flood Control Act of December 22, 1944 as amended in 1968.

The use of flows beyond the needs of the Upper Basin as additions to Upper Basin storage rather than being applied to potential consumptive use in the Lower Basin is clearly inefficient unless such storage provides insurance benefits for the future that more than offset the gains from current usage of the river, including those foregone by and attributable to evaporation losses at the storage reservoirs. Thus a fundamental question to raise concerning the management of the Colorado River system is that of an optimal policy for storing water in the system. It is clearly in the interests of Upper Basin states to store as much water as possible during periods of time in which Upper Basin depletions fall short of the allocation under the Compact. Likewise it is in the interest of the Upper Basin to locate a dam like Glen Canyon far enough south so that all Upper Basin tributaries can be controlled. However, neither of these actions may be socially desirable.

One interesting consequence of the storage accumulation over the past ten years is the possibility in the near future that the Lower Basin might have to bear the brunt of the variability of stream flows. With storage at capacity in the Upper Basin, excess flows to the Lower

Basin can tax the capacity of the Lower Basin to store and/or use on a current basis, water that is delivered to it. Since the Upper Basin is only held to a ten-year requirement, large flows in one or two years can be used to offset small flows in future years. Even with adequate storage capacity available in the Lower Basin, the effect of a highly variable policy of flows from the Upper Basin is to transfer to the Lower Basin the cost, in terms of evaporation losses, of providing insurance as to a more or less constant flow of water for consumptive use within the Lower Basin. The full implications of the incentive structure of the Compact so far as storage of water is concerned, deserve detailed study.

The rules for sharing shortages among the individual states have been elaborated above. Recapitulating, the Lower Basin states are prorated downward in proportion to their rights; Upper Basin states follow a more complicated formula based on previous use or overuse of water. For users within Upper Basin states the likelihood of curtailment depends on the priority of the right. Unfortunately, due to the large number of small users, it is not possible to delineate the order of priorities for users in those states. In the Lower Basin states the existence of a small number of large contracts renders the situation more tractable. Table 7 presents the priorities to use of Colorado River water in California in order of decreasing seniority.

Priority dates for various water uses in Arizona are still in dispute and have not yet been fully established by the courts. Article VI of the Supreme Court Decree in Arizona v. California called for Arizona,

California, and the United States to prepare lists of present perfected rights, with claimed priority dates, in terms of consumptive use of mainstream waters in each state. Lists of present perfected rights were submitted by the three states and the United States, but because of various reasons, they have not been able to reach agreement on their claims and have continued to assemble and exchange information in an effort to reach agreement. At the present time, the parties are considering a draft stipulation for present perfected rights including miscellaneous claims, and approval of the stipulation is expected in the near future. In addition, numerous rights have been perfected by contract, decree, or federal project with priority dates subsequent to June 25, 1929.

Table 8 shows rights of current and projected uses relative to the Central Arizona Project. Table 9 shows the projected operation of the Colorado River with addition of CAP diversions. Information concerning priorities of rights for Nevada's share of the Colorado River has not yet been obtained.

In summation several problems are obvious. In the Upper Basin overallocation of the Colorado River will occur in the next five to fifteen years. This will be hastened due to the resurrection of federal and Indian reserved rights, and the presence of large evaporative losses due to high Upper Basin storage levels. Shortages in the Upper Basin diminish even further the possibility of deliveries to the Lower Basin in excess of requirements. With this in mind the Lower Basin supplies will be drastically overallocated with the commencement of CAP flow in 1985. The catalysts which ensure this occurrence are the recognition

of federal and Indian reserved rights, the failure to account for Mexican requirements vis-a-vis the allocations to individual states, and the neglect of evapotranspiration and channel losses concomitant to Mexican deliveries. Realization of these circumstances will highlight the social costs of maintaining high storage levels in both basins.

APPENDIX:

TABLES 1 THROUGH 9

TABLE 1
UPPER COLORADO BASIN -- DEPLETIONS, CHANGES IN STORAGE, EVAPORATION LOSSES, AND VIRGIN FLOW AT LEE FERRY, 1896-1795
(All Figures in Thousands of Acre-Feet)

Year Ending 9/30	Historical Flow at Lee Ferry	Upper Basin Depletions			Changes in Storage					Net Evaporative Loss	Virgin Flow
		Total	Within Basin	Trans-Basin	Total	Transbasin Reservoirs	Surface Storage	Bank Storage	Other		
1896	9,760	329	329								10,089
97	17,500	509	509								18,009
98	13,300	515	515								13,815
99	15,250	624	624								15,874
1900	12,600	628	628								13,228
01	12,900	682	682								13,582
02	8,740	653	653								9,393
03	13,950	857	855	2							14,807
04	14,700	945	942	3							15,645
1905	15,000	1,027	1,020	7							16,027
06	17,964	1,157	1,144	13							19,121
07	22,003	1,399	1,385	14							23,402
08	11,763	1,093	1,076	17							12,856
09	21,706	1,569	1,552	17							23,275
1910	12,969	1,279	1,265	14							14,248
11	14,622	1,406	1,389	17							16,028
12	18,880	1,640	1,624	16							20,520
13	12,994	1,479	1,401	78							14,473
14	19,335	1,887	1,763	124							21,222
1915	12,500	1,528	1,465	63							14,028
16	17,325	1,876	1,771	105							19,201
17	21,893	2,145	2,055	90							24,038
18	13,650	1,714	1,651	63							15,364
19	10,858	1,605	1,532	73							12,463
1920	19,739	2,212	2,093	119							21,951
21	20,717	2,301	2,193	108							23,016
22	16,302	2,004	1,905	99							18,306
23	16,261	2,009	1,905	104							18,270
24	12,481	1,721	1,672	49							14,202
1925	11,341	1,693	1,631	62							13,034

TABLE 1
(Continued)

Year Ending 9/30	Historical Flow at Lee Ferry	Upper Basin Depletions			Changes in Storage					Net Evaporative Loss	Virgin Flow
		Total	Within Basin	Trans-Basin	Total	Transbasin Reservoirs	Surface Storage	Bank Storage	Other		
1926	14,008	1,845	1,768	77							15,853
27	16,587	2,030	1,919	111							18,617
28	15,323	1,957	1,851	106							17,280
29	19,223	2,206	2,097	109							21,429
1930	13,070	1,816	1,740	76							14,886
31	6,388	1,381	1,339	42							7,769
32	15,286	1,958	1,864	94							17,244
33	9,745	1,612	1,533	79							11,357
34	4,396	1,245	1,215	30							5,641
1935	9,912	1,638	1,547	91							11,550
36	11,970	1,831	1,671	160							13,801
37	11,897	1,843	1,670	173							13,740
38	15,440	2,106	1,892	214							17,546
39	9,394	1,685	1,532	153							11,079
1940	7,082	1,519	1,380	139							8,601
41	16,052	2,097	1,919	178							18,149
42	17,029	2,097	1,974	123							19,126
43	11,263	1,841	1,643	198							13,104
44	13,221	1,934	1,767	167							15,155
1945	11,545	1,866	1,657	209							13,411
46	8,745	1,681	1,490	191							10,426
47	13,514	1,957	1,780	177							15,471
48	13,687	1,926	1,781	145							15,613
49	14,359	2,017	1,824	193							16,376
1950	11,057	1,837	1,626	211							12,894
51	9,831	1,816	1,554	262							11,647
52	17,980	2,348	2,092	256	337	337					20,665
53	8,805	1,907	1,513	394	- 76	- 76					10,636
54	6,116	1,842	1,343	499	-297	-297					7,661
1955	7,307	1,922	1,431	491	- 41	- 41					9,188

TABLE 1
(Continued)

Year Ending 9/30	Historical Flow at Lee Ferry	Upper Basin Depletions			Changes in Storage					Net Evaporative Loss	Virgin Flow
		Total	Within Basin	Trans-Basin	Total	Transbasin Reservoirs	Surface Storage	Bank Storage	Other		
1956	8,750	1,993	1,520	473	6	6					10,749
57	17,340	2,482	2,059	423	273	273					20,095
58	14,260	2,233	1,851	382	- 4	- 4					16,489
59	6,756	1,918	1,394	524	- 65	- 65					8,609
1960	9,192	2,060	1,548	512	11	11					11,263
61	6,674	1,797	1,390	407	- 14	- 14					8,457
62	14,785	2,391	1,896	495	123	81	38	4			17,299
63	2,520	1,876	1,390	486	4,015	-197	3,738	474		39	8,450
64	2,427	2,078	1,481	597	5,507	- 51	4,389	1,169		144	10,156
1965	10,835	2,596	2,096	500	5,245	452	3,558	977	258	237	18,913
66	7,870	2,568	2,084	484	462	-250	3	884	-175	307	11,208
67	7,823	2,663	2,109	554	1,133	83	553	437	60	288	11,907
68	8,358	2,613	2,142	471	2,386	137	1,251	659	339	307	13,664
69	8,850	2,600	2,134	466	2,576	203	2,071	291	11	360	14,386
1970	8,688	2,625	2,139	486	3,682	104	2,579	929	70	410	15,405
71	8,607	2,667	2,130	537	3,096	9	2,164	860	63	476	14,846
72	9,330	2,770	2,152	618	-653	- 50	- 704	180	- 79	494	11,941
73	10,141	2,833	2,154	679	5,805	95	5,209	313	188	548	19,327
74	8,277	2,789	2,172	617	1,163	- 94	619	918	-280	615	12,844
1975 1/	9,274	2,849	2,176	673	4,018	+ 35	+2,761	941	+281	630	16,771

1/ Provisional records subject to revision.

TABLE 2
AVAILABILITY AND USES OF MAINSTREAM WATER -- LOWER BASIN
1964-1973 WATER YEARS
(All Figures in Thousands of Acre-Feet)

	AVAILABILITY				USES						
Water Year	Historical Inflows Lees Ferry	Net Inflow L. Ferry-L. Mead	Inflow* L. Mead N. Border	Total Water Avail.	Change In Surface Storage	Change In Bank Storage	Reservoir Evap. Losses	Net** Diversions In L. Basin	Channel & Other Losses***	Flow at N. Border	Total Uses
1964	2,414	751	35	3,200	-5,514	-354	709	6,359	381	1,617	3,198
65	10,820	821	119	11,760	2,947	189	603	6,252	315	1,454	11,760
66	7,854	916	224	8,994	304	18	680	6,182	300	1,511	8,995
67	7,797	987	68	8,852	275	17	643	6,406	179	1,331	8,851
68	8,334	847	65	9,246	634	42	634	6,267	345	1,323	9,245
69	8,823	1,065	39	9,927	1,170	72	683	6,391	300	1,310	9,926
1970	8,672	656	23	9,351	563	41	712	6,453	288	1,293	9,350
71	8,591	577	17	9,185	200	8	770	6,773	123	1,313	9,187
72	9,311	383	7	9,701	517	37	759	7,000	71	1,317	9,700
73	10,108	1,676	268	12,052	2,731	177	866	6,753	274	1,250	12,051
10 Yr. Avg.	8,272	868	87	9,227	383	25	706	6,484	258	1,372	9,227

Source: Based on communication from Alden Briggs, U.S. Bureau of Reclamation.

* Bill Williams River and Gila River.

** Equal to consumptive use (diversions less returns) except that Mohawk-Wellton returns bypassing Morales Dam are not deducted.

*** Includes channel evaporation losses, unmeasured inflows, diversions and return flows not otherwise accounted for, changes in channel, surface and bank storage, except in reservoirs.

(Note: Flow at North Border equals deliveries to Mexico less returns to river between the North and South borders that are creditable to Mexico under the treaty provisions. This amounts to around 140,000 acre-feet per year.)

TABLE 3

CONSUMPTIVE USE -- LOWER COLORADO BASIN

1964-1974

(Thousands of Acre-Feet)

Cal. Year	Total (Excl. Mexico)	California	Arizona	Nevada	Diversions To Mexico
1964	6,217.2	5,064.7	1,127.2	25.3	n.a.
1965	5,931.2	4,900.0	1,008.5	22.7	1,687.7
1966	6,196.7	5,096.9	1,073.1	26.7	1,656.1
1967	5,958.3	4,886.7	1,042.4	27.2	1,559.0
1968	6,203.5	5,072.5	1,097.4	33.6	1,562.7
1969	6,061.0	4,896.5	1,127.1	37.4	1,565.8
1970	6,240.1	5,015.0	1,186.8	38.3	1,583.2*
1971	6,522.7	5,174.3	1,297.8	50.6	1,561.6*
1972	6,547.0	5,230.6	1,235.3	81.1	1,612.5*
1973	6,682.0	5,317.5	1,271.9	92.6	1,625.2*
1974	6,834.5	5,414.0	1,325.6	94.9	1,665.4*

*Diversions to Mexico include water delivered pursuant to Minute 241 of U.S.-Mexico agreement of amounts: 54.6 (1970); 55.2 (1971); 86.3 (1972); 119.1 (1973); 159.2 (1974).

Source: Compilation of Records in Accordance with Article V of the Decree of the U.S. Supreme Court in Arizona V. California, March 9, 1964. Annual issues, 1964-1974, U.S. Bureau of Reclamation.

TABLE 4

USERS OF LOWER BASIN WATER, BY STATES, 1964-1974

(Thousands of Acre-Feet)

Calendar Year	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
CALIFORNIA											
Total	5064.7	4900.0	5096.9	4886.7	5072.5	4896.5	5015.0	5174.3	5230.6	5317.5	5414.0
MWD of So. Calif.	1134.5	1178.1	1146.2	1122.6	1181.5	1128.6	1200.4	1212.0	1212.0	1170.1	1121.8
Palo Verde Irr. Dist.	397.8	350.8	404.6	363.5	393.5	393.7	410.1	458.6	439.6	465.3	458.4
Yuma Res. Dist.	72.6	63.5	69.0	67.5	74.2	65.0	66.7	62.9	58.0	64.3	60.6
Imperial Valley Irr. Dist.	2891.2	2741.3	2944.5	2819.7	2895.5	2766.9	2848.6	2932.5	2965.9	3047.9	3172.0
Coachella Valley Irr. Dist.	526.4	524.7	489.4	464.1	478.6	495.1	449.3	464.4	511.5	522.4	558.9
Other	42.2	41.7	43.2	49.4	49.3	47.3	40.1	43.8	39.4	48.1	42.5
ARIZONA											
Total	1127.2	1008.5	1073.1	1042.4	1097.4	1127.1	1186.8	1297.8	1235.3	1271.9	1325.6
Colo. River Indian Res.	180.0	161.5	202.0	204.8	232.8	218.6	228.2	297.2	269.2	303.2	298.4
No. Gila R. Irr. Dist.	39.9	36.0	44.3	40.2	41.0	40.4	44.9	45.0	44.7	49.4	51.3
Wellton-Mohawk Irr. Dist.	301.3	286.1	276.3	262.9	260.8	283.4	296.1	318.9	293.5	289.9	339.9
Yuma Co. Water Ass'n.	163.8	155.4	191.0	181.3	183.2	163.9	168.6	179.2	189.0	222.9	230.2
Yuma Mesa and So. Gila R.	284.6	235.8	219.8	213.5	234.7	253.7	269.1	260.7	240.3	251.2	255.1
Unit B Irr. Dist.	41.7	37.9	40.3	37.9	39.4	37.5	40.2	40.8	38.5	38.5	39.8
Havasu Nat'l Wildlife Res.	-	-	-	-	-	28.6	36.1	32.3	35.8	40.8	31.9
Other	96.9	95.8	99.4	101.8	105.3	111.0	103.5	123.7	124.3	76.0	79.0
NEVADA											
Total	25.3	22.7	26.7	27.2	33.6	37.4	38.3	50.6	81.1	94.6	98.9
Basic Mgt. Inc.	16.2	16.1	18.1	18.8	22.9	24.0	20.9	19.7	19.7	19.8	19.3
Las Vegas Water Dist.	5.9	3.6	5.3	4.6	6.9	9.7	13.4	20.7	42.7	49.7	49.6
Other	4.2	3.0	3.3	3.8	3.8	3.7	4.0	10.2	18.7	25.1	30.0

Source: Compilation of Records in Accordance with Article V of the Decree of the U.S. Supreme Court in Arizona V. California, March 9, 1964. Annual issues, 1964-1975, U.S. Bureau of Reclamation.

TABLE 5
ACTIVE STORAGE LEVELS -- COLORADO RIVER RESERVOIRS
1964-1975
(Thousands of Acre-Feet)

	Upper Basin							Lower Basin			
	Total	Lake Powell	Flaming Gorge	Navajo	Blue Mesa	Fonte-Nelle	Morrow Point	Total	Lake Mead	Lake Mohave	Lake Havasu
1964	5,966	4,214	1,460	253	-	14	-	13,510	11,623	1,321	546
1965	9,529	6,466	2,475	570	-	18	-	16,635	14,708	1,377	550
1966	9,427	6,423	2,454	334	192	24	-	16,956	15,004	1,387	565
1967	9,971	6,300	2,731	451	430	17	-	16,337	14,375	1,402	560
1968	11,509	7,514	2,119	848	658	303	67	16,967	15,018	1,395	536
1969	13,725	9,708	1,826	1,144	720	286	41	18,137	16,131	1,441	565
1970	16,264	12,039	1,793	1,261	810	246	117	18,702	16,769	1.176	537
1971	18,509	13,609	2,931	993	532	327	117	18,901	16,886	1,441	574
1972	17,820	12,488	3,465	898	511	343	116	19,419	17,543	1,404	564
1973	23,025	17,284	3,180	1,393	716	337	115	22,150	20,176	1,412	562
1974	23,609	18,011	3,583	1,010	578	315	112	21,301	19,358	1,380	563
1975	26,385	20,202	3,650	1,393	695	329	116	22,112	20,154	1,385	573

Source: Annual Reports, Colorado River Board of California, 1964-1975.

TABLE 6

CHANGES IN ACTIVE STORAGE -- COLORADO RIVER RESERVOIRS

1964-1975

(Thousands of Acre-Feet)

Change From Previous Year (9/30)	Upper Basin							Lower Basin			
	Total	Lake Powell	Flaming Gorge	Navajo	Blue Mesa	Fonte-Nelle	Morrow Point	Total	Lake Mead	Lake Mohave	Lake Havasu
1964-1965	+ 3,563	+ 2,252	+ 990	+ 317	-	+ 4	-	+3,125	+3,085	+36	+ 4
1965-1966	- 102	- 43	- 21	- 236	+192	+ 6	-	+ 321	+ 296	+10	+15
1966-1967	+ 544	- 63	+ 259	+ 117	+238	- 7	-	+ 275	+ 265	+15	- 5
1967-1968	+ 1,537	+ 1,154	- 595	+ 397	+228	+286	+ 67	+ 631	+ 643	- 9	- 3
1968-1969	+ 2,053	+ 2,194	- 293	+ 133	+ 62	- 17	- 26	+1,170	+1,113	+48	+ 9
1969-1970	+ 2,538	+ 2,331	- 35	+ 117	+ 90	- 41	+ 76	+ 565	+ 638	-65	- 8
1970-1971	+ 2,245	+ 1,570	+1,140	- 268	-278	+ 81	0	+ 199	+ 117	+65	+17
1971-1972	- 689	- 1,121	+ 534	- 95	- 21	+ 15	- 1	+ 518	+ 565	-37	-10
1972-1973	+ 5,205	+ 4,796	- 285	+ 495	+205	- 5	- 1	+2,731	+2,725	+ 8	- 2
1973-1974	+ 584	+ 727	+ 403	- 383	-138	- 22	- 3	- 849	- 818	-32	+ 1
1974-1975	+ 2,776	+ 2,191	+ 67	+ 383	+117	+ 14	+ 4	+ 811	+ 796	+ 5	+10
1964-1975	+20,519	+16,088	+2,165	+1,140	+695	+315	+116	+8,602	+8,531	+44	+27

Source: Annual Reports, Colorado River Board of California, 1964-1975.

TABLE 7

PRIORITIES TO USE OF COLORADO RIVER WATER IN CALIFORNIA UNDER SEVEN-PARTY AGREEMENT OF AUGUST 18, 1931

Priority No.	Agency and description	Annual quantity in acre-feet
1.	Palo Verde Irrigation District—104,500 acres in and adjoining existing district	3,850,000
2.	Yuma Project (California Division)—not exceeding 25,000 acres	
3.	(a) Imperial Irrigation District and lands in Imperial and Coachella Valleys to be served by All-American Canal	
	(b) Palo Verde Irrigation District—16,000 acres of adjoining mesa	
4.	Metropolitan Water District, City of Los Angeles and/or others on the coastal plain	550,000
5.	(a) Metropolitan Water District, City of Los Angeles and/or others on the coastal plain	550,000
	(b) City and/or County of San Diego	112,000
6.	(a) Imperial Irrigation District and lands in Imperial and Coachella Valleys to be served by All-American Canal	300,000
	(b) Palo Verde Irrigation District—16,000 acres of adjoining mesa	
	Total	5,362,000

A seventh priority with respect to all remaining water available for use in California was apportioned for agricultural use in the Colorado River Basin in California as shown on Map No. 23,000 of the Department of the Interior, Bureau of Reclamation.

TABLE 8

CENTRAL ARIZONA PROJECT
WATER SUPPLY STUDIES

Estimated Future Colorado River Mainstream Use in Arizona
Hoover to International Boundary

Project or User	Est. Consumptive Use (1000 af) Development Year 1980	2000	2030
Rights prior to C.A.P.			
1. Indian Reservations	435.2	458.9	458.9
a. Colorado River	(397.5)	(397.5)	(397.5)
b. Cocopah	(1.7)	(1.7)	(1.7)
c. Fort Mohave	(36.0)	(59.7)	(59.7)
2. Yuma Project	220.0	220.0	220.0
3. Gila Project	449.4	449.4	449.4
4. City of Yuma	10.0	20.0	30.0
5. Havasu Lake Nat. Wildlife Refuge	37.3	37.3	37.3
6. Cibola National Wildlife Refuge	16.8	16.8	16.8
7. Imperial National Wildlife Refuge	12.6	12.6	12.6
8. Misc. & Supplemental Claims	5.0	5.0	5.0
Total	1,186.	1,220.	1,230.
Rights or contracts assumed equal to C.A.P.			
1. City of Kingman	0	1.0	18.5
2. Havasu Irrig. & D.D.	4.0	10.0	10.0
3. Mohave Valley I.& D.D.	19.0	33.0	36.0
Total	23.0	44.0	64.5

Note: Additional requests under consideration.

TABLE 8 (continued)

Explanation of Sheet 1

Rights prior to C.A.P.

		Est. Future Acreage-Acres 1980	2000	2030
1.	Indian Reservations			
	a. Colorado River	99,375	99,375	99,375
	b. Cocopah	431	431	431
	c. Fort Mohave	9,000	14,916	14,916
2.	Yuma Project 1/	55,000	55,000	55,000
3.	Gila Project 2/	112,340	112,340	112,340

4. City of Yuma - Based on present and estimated future population growth.

5. Decreed consumptive use.

6. C. U. requirement as stated in Senate Report No. 408, 90th Congress, 1st Session, p. 49.

7. Decreed C. U. of 23,000 af/yr prorated as 12,600 to Arizona, and 10,400 to California.

8. Represents C. U. for about 1,250 acres supportable as having present perfected rights.

Other Rights

1. Kingman - Assumes nominal use in 2000 and full depletion of maximum contract diversion in 2030. Maximum contract diversion is 18,500 af/yr.

2. Havasu I.& D.D. - Assumes full contract diversion by 2000 with 30% return flow. Maximum contract diversion is 14,500 af/yr.

3. Mohave Valley I. & D.D. - Assumes 30% return flow, with full contract diversion in 2030. 1970 acreage was 3,438 acres, or 13,750 AF C.U. @ 4.0 af/ac. Maximum contract diversion is 51,000 af/yr.

1/ Includes 3,406 acres in Yuma Auxiliary Project.

2/ 1969 USBR Status Data.

TABLE 9
ARIZONA WATER COMMISSION

Summary of
Colorado River Operation and Water Supply Studies

(Averages for 1906-1970 Period, in 1,000 AF)

August 1973

Item	Year 1980	Year 2000	Year 2030	Average 1980-2030
Glen Canyon Releases	10,224	9,467	9,268	9,559
Net Gain, Glen Canyon to Hoover	820	800	777	797
Lake Mead:				
Inflow	11,044	10,267	10,045	10,356
Evaporation	818	714	708	733
Spills	505	204	122	240
Regulated Releases	9,721	9,349	9,215	9,383
Net Losses, Hoover to Mexico	605	555	555	565
Delivery to Mexico	1,500	1,500	1,500	1,500
Available for use in U.S.	7,616	7,294	7,160	7,318
California	4,545	4,516	4,522	4,524
Nevada	161	196	286	216
Arizona	2,910	2,582	2,352	2,578
Other than CAP:				
Rights prior to CAP	1,186	1,220	1,230	1,216
Rights assumed equal to CAP	54	84	84	78
Central Arizona Project Diversion (3,000 cfs aqueduct max.)	1,670	1,278	1,038	1,284
System losses (10%)	167	128	104	128
Supplied from Colorado River	1,503	1,150	934	1,156
Supplied from Gila River	50	50	50	50
Project Deliveries	1,553	1,200	984	1,206